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SPACE STATION OPERATIONS TASK FORCE FINAL REPORT:

EXECUTIVE SUMMARY

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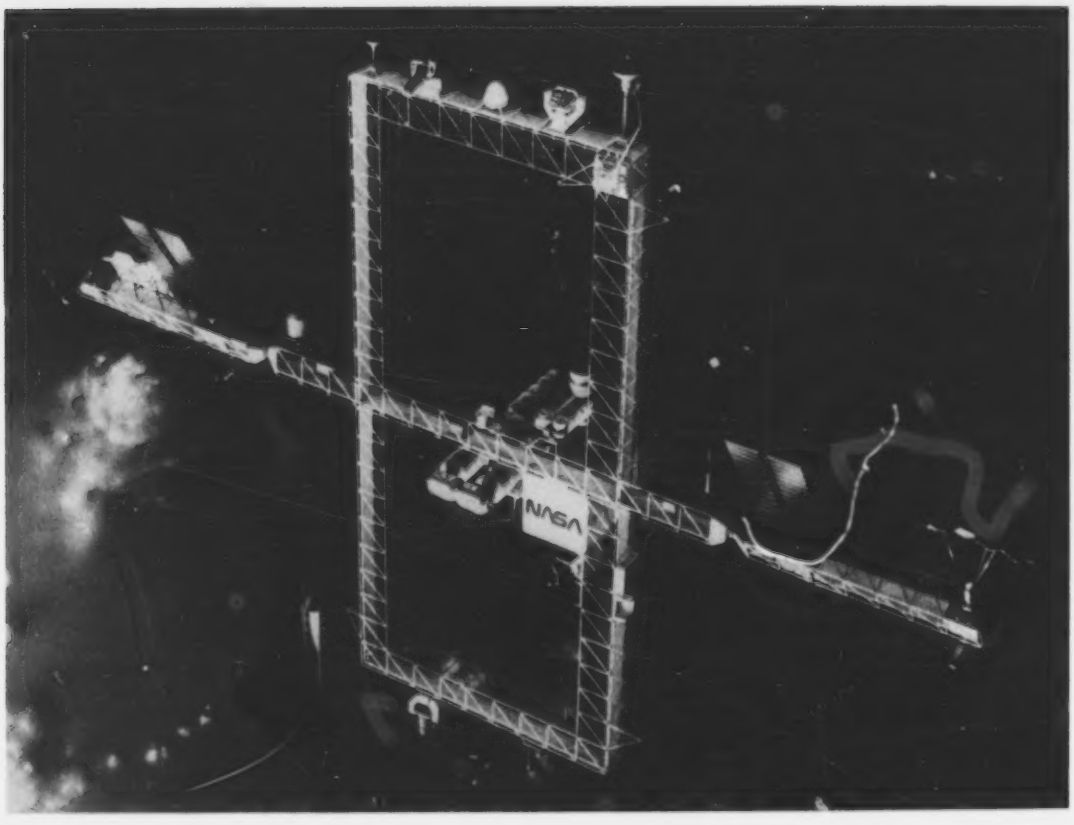

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NASA
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Space Administration

SPACE STATION OPERATIONS TASK FORCE

FINAL REPORT:

EXECUTIVE SUMMARY

OCTOBER, 1987

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

TABLE OF CONTENTS

PAGE

I. INTRODUCTION 1

II. PROGRAM GOALS AND OPERATIONS EVALUATION CRITERIA 1

III. RECOMMENDED FRAMEWORK FOR OPERATIONS 2

A. Manned Base Operations 4

1. Strategic Utilization and Operations Planning 5
2. Tactical Utilization and Operations Planning 6
3. Increment Planning and Execute Planning 6
4. Operations Execution 7

B. Platform Operations 8
C. Roles and Responsibilities 9

IV. SPECIAL TOPICS 11

A. Program Observations 11
B. Program Observations Costs 11
C. International Issues 11
D. Proprietary User Operations 11
E. Station/STS Operations Synergy 12
F. Safety 12
G. Pricing Policy 12
H. Crew Training 13
I. The Space Station Information System (SSIS) 13
J. Space Station Management Information System 13

V. RECOMMENDATIONS FOR IMPLEMENTATION 14

LIST OF FIGURES & TABLE

FIGURE	NAME	PAGE
1	Manned Base Operations Infrastructure	2
2	Platform Operations Infrastructure	3
3	Operations Functions	4
4	Space Station Program Hierarchy	5
5	Recommended Framework Planning and Control Hierarchy	6
6	Summary: Manned Base Operations Framework	10
7	COP and POP Mission Operations Framework Overview	10
8	Space Station Program Mature Operations Organization	15
9	Space Station Transition Operations Organization	15

TABLE

1	Space Systems Sustaining Engineering Responsibilities	19

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GRAPHICS LEGEND NOTE

To aid reader understanding of the various Figures found throughout this report, a combination of color tones and computer-generated crosshatch has been used as graphics background enhancement. The following colors and crosshatch pattern represent a family of operations functions, products, organizations, or facilities associated with a particular aspect of Space Station Operations and are consistent in their representation throughout the report:

The Space Station User Community. . . . .

Space Station Program Policy Level. . . . .

Space Station Program Integration Level. . . . .

Space Station Program Execution Level. . . . .

Interface with a NASA Organization
Other than the Space Station Operations Organization. . . . .

Additional computer-generated shadings or symbols appear as required to uniquely support a particular figure and are self-explanatory.

SPACE STATION OPERATIONS TASK FORCE
FINAL REPORT: EXECUTIVE SUMMARY

I. INTRODUCTION

The Space Station is NASA's next major science and exploration initiative. It will expand our scientific pursuits, support development of new technologies, and provide the experience base necessary to evaluate and undertake more ambitious science and exploration missions. The manned and unmanned elements of the Station will operate as a laboratory, an observatory, a servicing and repair facility, and a staging area for future manned and unmanned exploration.

The Space Station Operations Task Force (SSOTF) was created in the fall of 1986 at the direction of the NASA Associate Administrator for Space Station to conduct a systematic assessment of Station operations. The SSOTF was co-chaired by Dr. Peter Lyman (JPL) and Mr. Carl Shelley (JSC); membership drew upon multi-program manned and unmanned operations expertise throughout the Agency. The Task Force analysis has accelerated and focused the Agency's operations planning efforts, and is a "critical mass" of information for the Program to begin implementation of its operations strategy and organization.[1] The Summary Report of the Space Station Operations Task Force is the end product of the SSOTF effort, with this Executive Summary highlighting the operations aspects addressed and the conclusions and recommendations of the Summary Report.[2]

II. PROGRAM GOALS AND OPERATIONS EVALUATION CRITERIA

The SSOTF's starting point was a definition of the operations goals of the Space Station Program. These goals can be grouped into four basic categories: (1) direct support of science, exploration and technology development through the provision of infrastructural resources (a manned base and unmanned platforms) and support services for user payloads; (2) supporting the dispersion of knowledge and technology advances gained from space activities into the national economy to leverage the benefit of new discoveries; (3) support for multi-discipline space utilization and exploitation by lowering the cost and complexity of space operations and increasing the flexibility of our space infrastructure; and (4) support of NASA's mandate to promote international cooperation through the peaceful exploration and utilization of space.

These are challenging goals from the operations perspective. The Station's user community will be extremely diverse, with resource requirements and "preferred operating modes" differing greatly among users.[3] Likewise, the benefits of sharing the development and operations costs of the Program through international participation are tempered by the added complexity which is an inherent aspect of any international effort.

The Task Force established a basis for selecting among various options for achieving these operations goals, through the definition and prioritization of six operations evaluation criteria. The criteria are objectives which were used to guide tradeoff analyses among alternative means of performing a given operational task. In order of importance, they are: Program Control; Program Safety and System Integrity; Effective User Operations; Substantive International Participation; Assembly and Evolution Applicability; and Operations Cost Effectiveness.

Program Control is a fundamental criterion for operations. It addresses the question: Can NASA and its partners adequately manage the Program in both normal and off-nominal situations in a timely and effective manner? Evaluations of Program Control options included assessments of whether there were clear and direct lines of management authority and accountability, and whether there was a manageable system for communicating operations information across the Program.

Program Safety and System Integrity are of equal importance to Program Control. Management and operation of ground and space hardware (including actions performed by the onboard crew and ground based experimenters) must be conducted in a manner consistent with the high value of the hardware and crew, and the 30-year life of the Program. This criterion was pervasive in all of the SSOTF evaluations.

Effective User Operations is a generalized criterion for determining whether the Station operations organization can provide the services which users need to meet their goals. Such "user-friendly" attributes as a well-understood set of payload safety specifications, the ability (and willingness) to replan an experimenter's schedule to take advantage of unanticipated results, the accommodation of "quick is beautiful" or the provision of an environment

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[1] *Likewise, a review of the operations environment provides valuable and timely input to the Space Station Development Phase, especially in ensuring that hardware and software design incorporate a "life cycle" perspective which includes system and user operations factors.*

[2] *Those readers wishing to examine the analyses conducted by the Task Force in developing its conclusions are referred to the Summary Report, and to the four detailed individual panel reports from which it was derived.*

[3] *Research disciplines supported on the Station will include life and materials sciences, earth observations, and physics and astronomy. In terms of demographic makeup, the Station will serve both U.S. and foreign users. They will come from every sector of the the research and development world (public, private and academic), and will be engaged in operations ranging from basic research to highly proprietary technology development or demonstration.*

responsive to his non-technical requirements (e.g., proprietary operations) are all illustrations of this criterion.

Substantive International Participation was a stand-alone criterion included because of the expressed desire of Canada, the European Space Agency, and Japan to use the Space Station to develop their own capabilities with regard to complex space flight systems (especially manned systems). This criterion was used to ensure that the operations concepts reviewed by the SSOTF supported international participation and met the desires of the foreign partners to the maximum extent feasible consistent with the previous criteria.

Assembly and Evolution Applicability incorporates the SSOTF philosophy that any operations framework recommended for the Mature Operations Phase must be easily adaptable to the Development Phase (from initial assembly to mature operations), as well as to the incorporation of system evolution (such as upgrades, additions or block changes). In order to enhance the utility of the Station, it is desirable that early science returns be achieved while the assembly sequence is being completed. Equally important, evolution of Station systems should not unduly disrupt utilization schedules.

Operations Cost Effectiveness was used as a final discriminating criterion when more than one acceptable option was available. The SSOTF strongly believed that cost, while an important consideration, should be a driver only in selecting among options which meet the other fundamental criteria noted above. In short, the Task Force did not consider an option to be cost-effective unless it also satisfied the other criteria (e.g., did not entail unacceptable safety risk, adversely affect the productivity of users, prohibit partners from realizing their long term goals, etc.).

III. RECOMMENDED FRAMEWORK FOR OPERATIONS

Space Station operations can be divided into three basic categories of activity: logistics operations support, space operations support and space operations. These are depicted for both the manned base and platforms in Figures 1 and 2.[4] Logistics operations support encompasses two primary types of activities: 1) integrated logistics support at a centralized launch site facility, and 2) prelaunch and postlanding processing of flight hardware performed at one or more launch site facilities as well as at distributed Science and Technology centers.

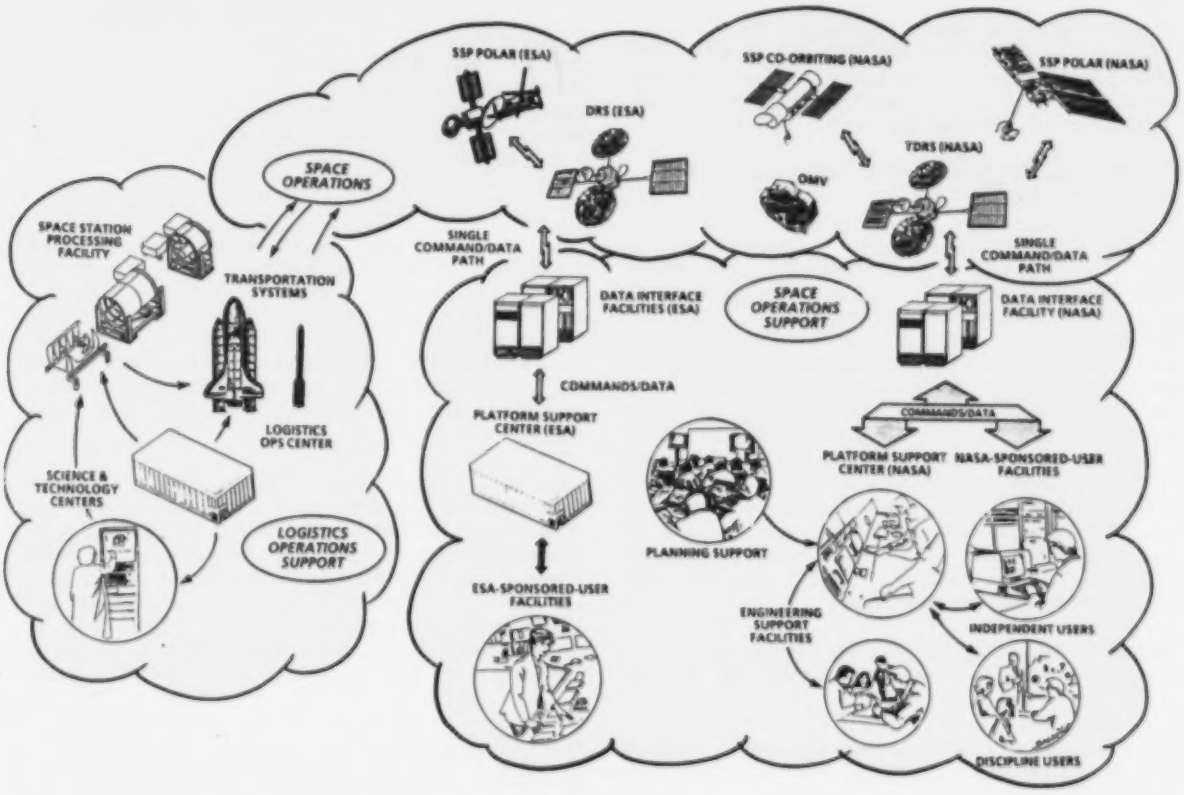

Figure 1 Manned Base Operations Infrastructure

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[4]The term "manned base" refers to the entire hardware complex on which the crew is located: it includes not only the pressurized modules, but also the mobile servicing center, unpressurized satellite servicing facility, trusses, and attached payloads. Unmanned platforms include the U.S. co-orbiting and polar platforms, and the ESA polar platform.

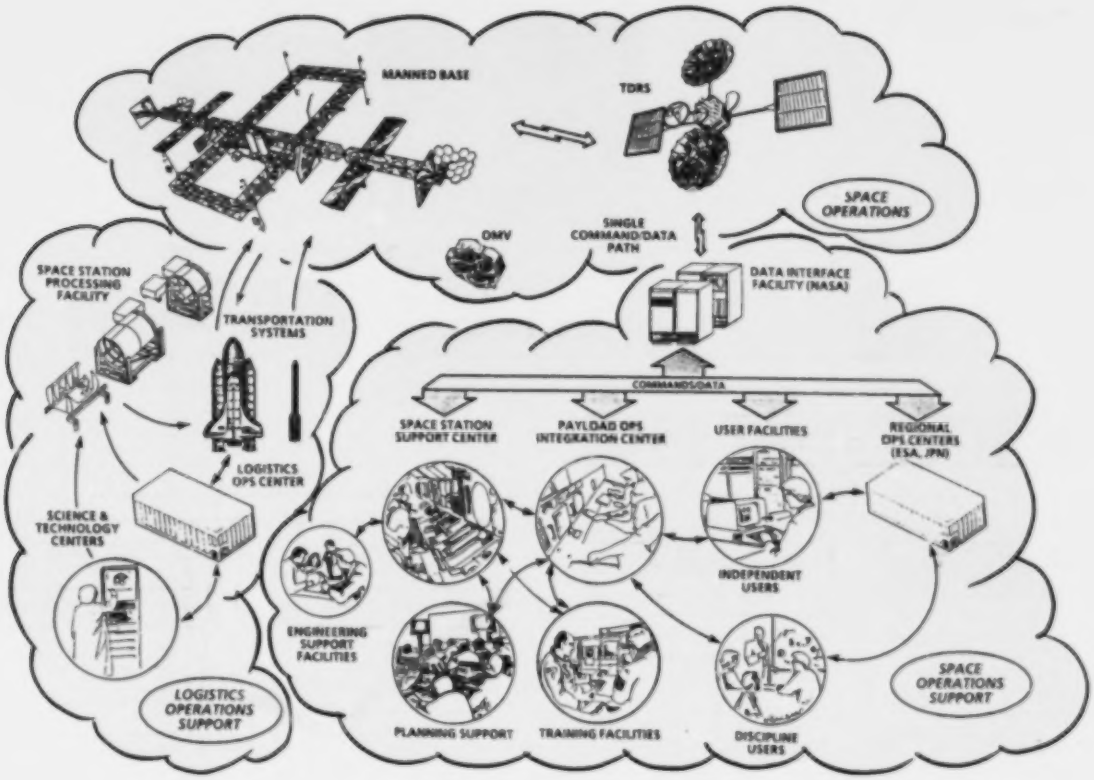

Figure 2 Platform Operations Infrastructure

Integrated logistics support will include the management, engineering, and support activities required to provide personnel and materials to the Space Station elements reliably and in a cost effective manner.

Prelaunch processing of user payloads at Science and Technology Centers is at the payload-to-rack integration level; at the launch site, racks are integrated into logistics transport elements along with other space systems consumables, orbital replacement units, and operational equipment and certified ready for handover to transportation systems personnel for launch to orbit.[5] Subsequently, launch site operations personnel retrieve and deintegrate this cargo as it is returned from space.

Space operations support activities are distributed to various NASA, international partner and user support centers and include the full complement of ground-based actions which support the Station on orbit. This will include such activities as operation and management of the communications up/down links to the Station, control of those hardware functions most effectively performed on the ground (e.g., routine systems monitoring), Station resource availability and utilization assessments, space systems and user operations planning, trajectory and altitude maintenance, and crew training and real-time support to crew members.

Space operations consists of all of the activities which transpire on orbit. This embodies all of the activity performed by the crew to maintain system integrity and to perform user support activities (setting up experiment hardware, performing experiments, etc.).

The Task Force examined these activities at a detailed functional level as summarized in Figure 3.[6] These functions were then arranged in "end-to-end" functional flows which began with a broad task (such as utilization and operations planning) and then identified the sequential and parallel subtasks required to perform the function.[7]

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[5] *The SSOTF assumed that the STS will be the sole means of access to the Station, but that the Recommended Framework would accommodate the use of other transportation vehicles without major impact on operations.*

[6] *A detailed analysis of operations functions is presented in Chapter III and Appendix B of the Summary Report.*

[7] *Utilization and operations planning is a function which is integral to the entire operations framework. Given the high cost of space operations (both in absolute and opportunity cost terms), pre-flight planning will be extensive. This includes planning for both the Station systems and user activities. The Recommended Framework for operations developed by the SSOTF is focused on the utilization and operations planning process and its transition to real-time operations.*

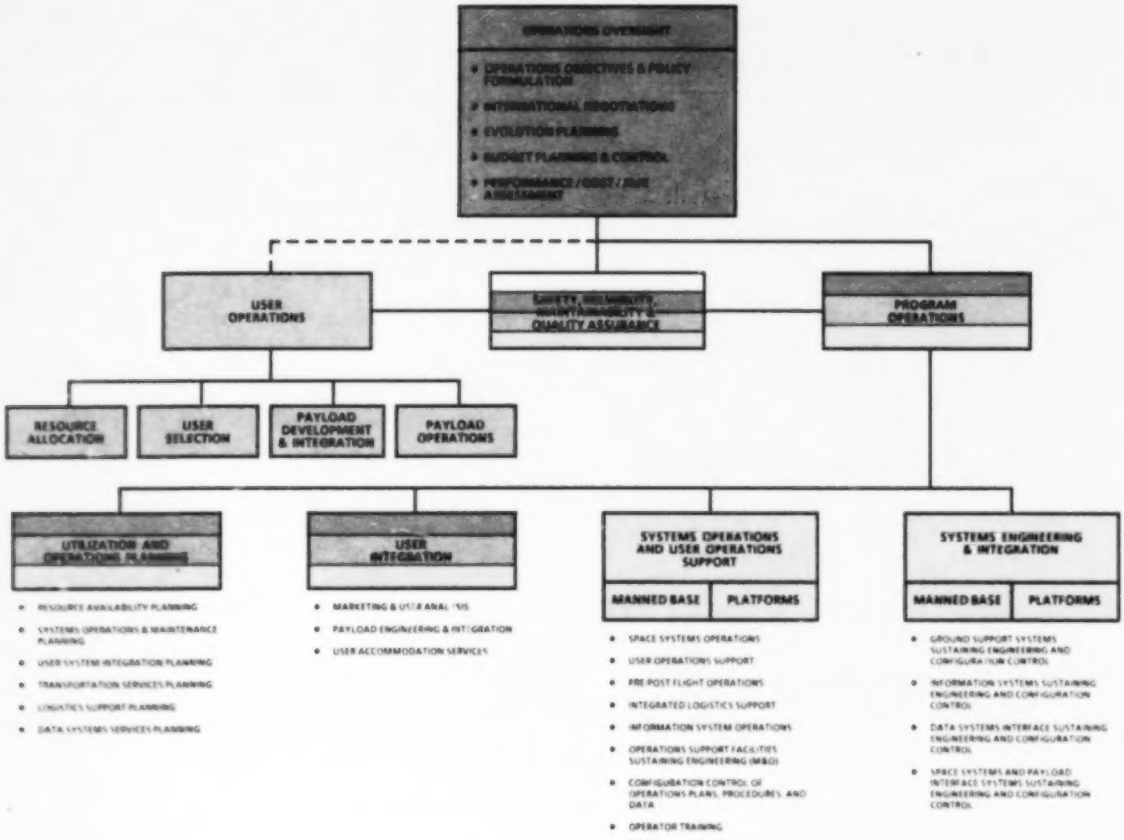
OPERATIONS OVERSIGHT
• OPERATIONS OBJECTIVES & POLICY FORMULATION
• INTERNATIONAL NEGOTIATIONS
• EVOLUTION PLANNING
• BUDGET PLANNING & CONTROL
• PERFORMANCE / COST / RISK ASSESSMENT
USER OPERATIONS
SAFETY, RELIABILITY, MAINTAINABILITY & QUALITY ASSURANCE
PROGRAM OPERATIONS
RESOURCE ALLOCATION
USER SELECTION
PAYLOAD DEVELOPMENT & INTEGRATION
PAYLOAD OPERATIONS
UTILIZATION AND OPERATIONS PLANNING
• RESOURCE AVAILABILITY PLANNING
• SYSTEMS OPERATIONS & MAINTENANCE PLANNING
• USER SYSTEM INTEGRATION PLANNING
• TRANSPORTATION SERVICES PLANNING
• LOGISTICS SUPPORT PLANNING
• DATA SYSTEMS SERVICES PLANNING
USER INTEGRATION
• MARKETING & USER ANALYSIS
• PAYLOAD ENGINEERING & INTEGRATION
• USER ACCOMMODATION SERVICES
SYSTEMS OPERATIONS AND USER OPERATIONS SUPPORT
MANNED BASE
PLATFORMS
• SPACE SYSTEMS OPERATIONS
• USER OPERATIONS SUPPORT
• PRE/POST FLIGHT OPERATIONS
• INTEGRATED LOGISTICS SUPPORT
• INFORMATION SYSTEM OPERATIONS
• OPERATIONS SUPPORT FACILITIES SUSTAINING ENGINEERING (MB&I)
• CONFIGURATION CONTROL OF OPERATIONS PLANS, PROCEDURES, AND DATA
• OPERATOR TRAINING
SYSTEMS ENGINEERING & INTEGRATION
MANNED BASE
PLATFORMS
• GROUND SUPPORT SYSTEMS SUSTAINING ENGINEERING AND CONFIGURATION CONTROL
• INFORMATION SYSTEMS SUSTAINING ENGINEERING AND CONFIGURATION CONTROL
• DATA SYSTEMS INTERFACE SUSTAINING ENGINEERING AND CONFIGURATION CONTROL
• SPACE SYSTEMS AND PAYLOAD INTERFACE SYSTEMS SUSTAINING ENGINEERING AND CONFIGURATION CONTROL

Figure 3 Operations Functions

The functions were then grouped in a three-tiered "management hierarchy" based on control requirements, product input/output requirements, skill requirements, the time horizon of interest to those performing the functions, and technical content of the functions. (See Figure 4.) Program Policy level functions are broad, have a low technical content, and speak to long term planning issues. The output, or "product" of these functions are the policies and directives for the operations organization with respect to utilization and operations. Program Integration level functions comprise the technical management and control tasks which require coordination across functions or operations centers (U.S. and Partner). The products of these functions are manifests and technical activity planning data completed prior to the initiation of a flight increment. Program Execution level functions include detailed operations execution planning (e.g., development of onboard crew timelines and procedures), and real-time operations execution and replanning.[8]

III.A. MANNED BASE OPERATIONS

The primary feature of the manned base framework is centralized utilization and operations planning at the Program Policy and Program Integration levels. Utilization and operations planning are managed by NASA across the Program, with Partner personnel working in the NASA-led operations management organization. This option was strongly preferred over a framework in which planning and operations execution for each Partner's element(s) was conducted under the direction of the element contributor. The SSOTF is convinced that the Recommended Framework offers a superior management and control structure, a safer operations environment, and is more responsive to overall user requirements. As well, the centralized approach suggests advantages in terms of assembly and growth considerations and operations cost effectiveness.[9]

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[8] *The control and product flow is presented here in a top- down fashion. Each level of activity develops a product which is used at the next lower level as guidance for its activity. This process continues until the end product (i.e., execution of operations) occurs. While it is not discussed in detail here, the hierarchy also has a reciprocal feedback path. Completion of execution operations is documented and passed upwards as a product which is used as input at the next higher level for development of a future operations planning product, and so on. In this way planners at the top of the hierarchy provide direction to "doers" at the bottom, who in turn produce the information which allows those at the top to gauge the efficiency of the Program in meeting goals.*

[9] *A comparison of these options is presented in Section IV.C of the Summary Report.*

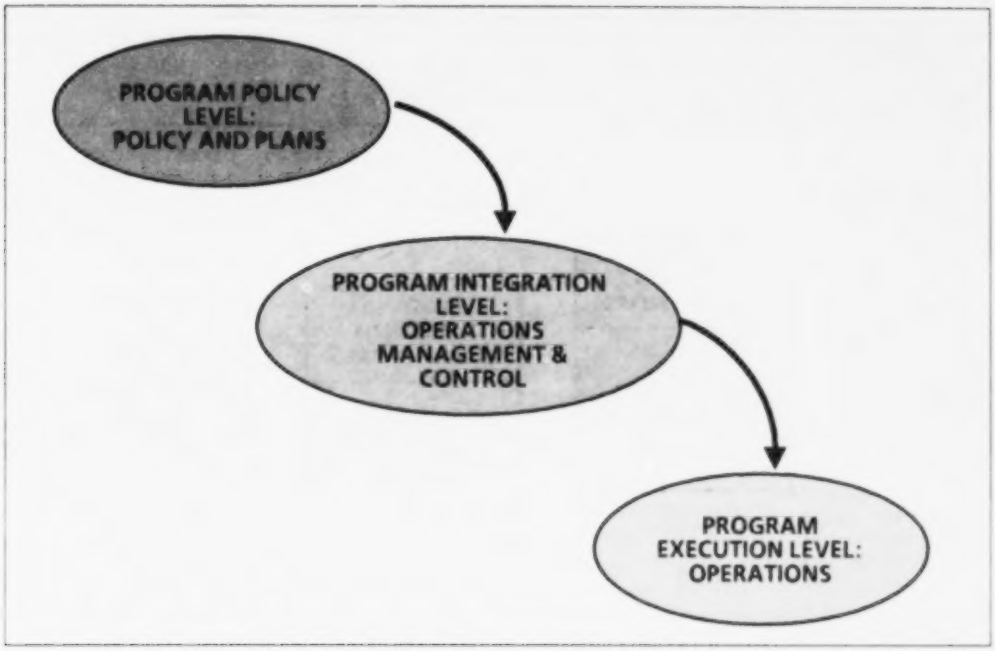
PROGRAM POLICY LEVEL: POLICY AND PLANS
PROGRAM INTEGRATION LEVEL: OPERATIONS MANAGEMENT & CONTROL
PROGRAM EXECUTION LEVEL: OPERATIONS

Figure 4 Space Station Program Hierarchy

The Recommended Framework is based on a hierarchical and sequential planning, control and execution process. This hierarchy is summarized in Figure 5. At the Program Policy level, long range planning (five-year horizon) is conducted under the auspices of a Multilateral Control Board. Program Integration Level functions are developed in two steps. Two year manifests are developed under the direction of a Program Operations Control Board (POCB); planning data for a specific flight increment are prepared by an Increment Management Team (IMT) which reports to the POCB. At the Program Execution level, detailed execute plans and operations are performed at the various operations control centers responsible for the specific activities.

III.A.1. STRATEGIC UTILIZATION AND OPERATIONS PLANNING

The Program's annual Consolidated Utilization Plan is the top level document for utilization and operations planning.[10] It contains the Program's "rough cut" of resource requirements for Station operations and the users selected to fly on the Station in the upcoming five years. The CUP is approved by the MCB (located at NASA Headquarters). It is chaired by the NASA Associate Administrator for Space Station Operations and staffed by NASA and its partners.

The CUP will be drafted by a Systems Operations Panel (SOP) and a Utilization Operations Panel (UOP). These panels will draw on the technical expertise located at the operations centers of the Program as required. The SOP will establish system requirements for the Station (including a safety reserve), and subtract them from the total resources available.[11] The remaining resources available for utilization (user activities) will be allocated in blocks to NASA and its partners on the basis of previously agreed memoranda of understanding. In the U.S., a Space Station User Board (SSUB) will be responsible for screening and approving user payload candidates. The SSUB will be chaired by non-Space Station Program personnel (rotating or as appointed by the NASA administrator), and will include representatives of the major classes of users, as well as Program personnel. It is assumed that the Partners will establish similar SSUBs, although the structure of these boards will be left to them to decide. The NASA and Partner SSUB payload "lists" will be reconciled by the UOP and then checked by the SOP for conformity with system requirements prior to their acceptance by NASA for subsequent flight increment assignment.

Every user accepted by NASA for Station flight and identified in the CUP becomes a member of the Space Station Users Working Group (SSUWG). The SSUWG is the primary source of user input for tactical utilization and operations planning. Users whose payloads have been selected for flight also will be assigned a Program-sponsored Payload Accommodation Manager (PAM). The PAM provides the single point of contact for an individual user through his entire "life cycle" with the Program.

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[10] *Annual production was the average interval endorsed by the SSOTF. More frequent updates could be provided if required.*

[11] *This includes resources (such as crew time and electrical power) required to maintain the baseline systems in sound operating condition or to support systems growth as well as those associated with transportation and data systems capabilities (up/down mass, network resources).*

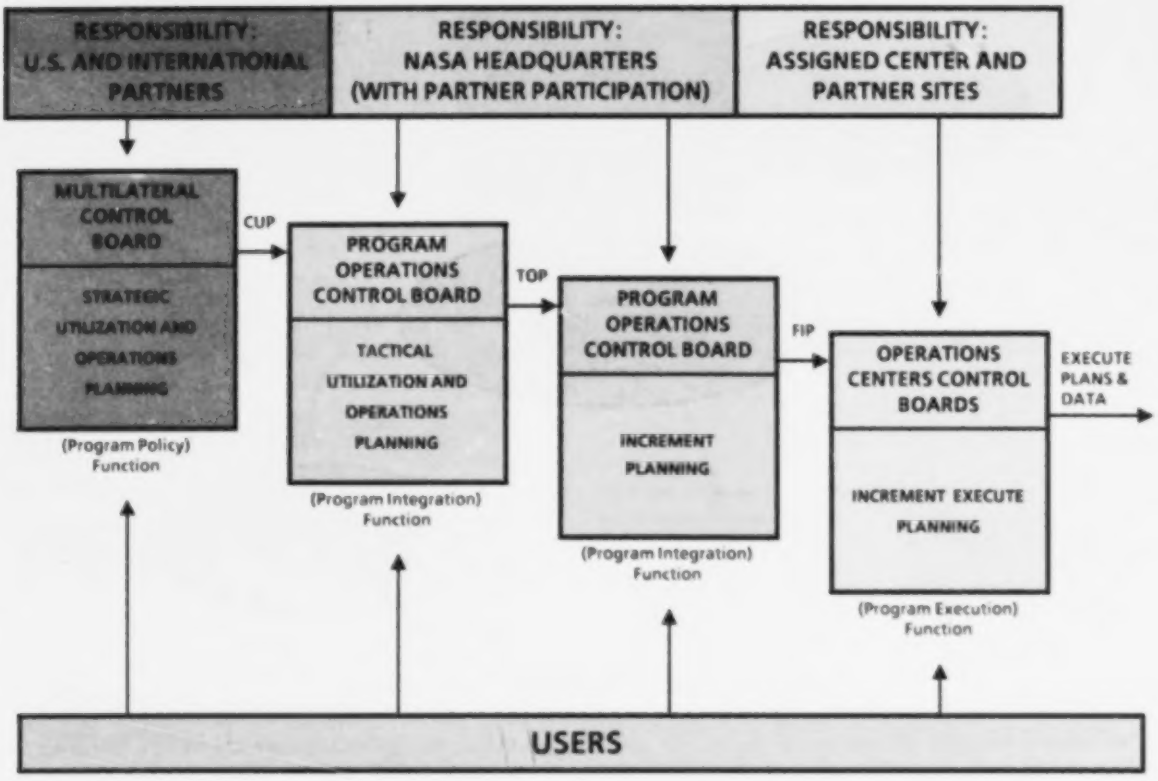

Figure 5 Recommended Framework Planning and Control Hierarchy

III.A.2. TACTICAL UTILIZATION AND OPERATIONS PLANNING

The next step in the utilization and operations planning process is the assignment of selected user and system payloads to a two year manifest known as the Tactical Operations Plan (TOP). The TOP is a collection of flight increment manifests, including the transportation and data systems requirements to be developed with the relevant non-Program offices.[12] The TOP is frequently revised, with a new TOP issued at the initiation of each new flight increment.

This activity is the responsibility of the Program Operations Control Board (POCB), which approves the TOP. The POCB is chaired by the NASA Director for Utilization and Operations, and staffed by NASA and its partners. It is located at NASA Headquarters in order to more effectively coordinate planning activities across NASA and partner operations centers. Like the MCB, the POCB also has two panels responsible for system and user oriented analysis: the Systems Control Panel (SCP) and the Utilization Control Panel (UCP). They will draw on the technical expertise of the operations organization for the performance of necessary technical assessments.

The SCP develops the increment manifests for Space Station systems (on-orbit maintenance and system upgrades, logistics, data, and transportation systems availability and requirements). Resources required to perform systems-oriented tasks are subtracted from each increment, with the remaining resources allocated to specific payloads by the UCP. A steering group selected by the SSUWG will be responsible for providing input to the UCP in the prioritization of payloads and their assignment to specific flight increments.

An independent safety review board will conduct a safety review of SCP and UCP plans. The safety review board will be staffed with Program personnel, but will be chaired by NASA's independent SRM&QA organization. The SCP, with UCP support, will reconcile any inconsistencies identified at the manifest level of detail, and submit the draft TOP to the POCB for review and approval.

III.A.3. INCREMENT PLANNING AND EXECUTE PLANNING

The TOP becomes the basis for Increment Planning. The primary emphasis of Increment Planning is on

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[12] *A flight increment is defined as the period of time between STS visits to the manned base. The SSOTF assumed eight STS flights per year, leading to a 45-day increment and 16 increments in each TOP. The Framework is equally applicable to lower STS-manned base flights (for example, six flights per year translates into 60-day increments and twelve increments in each TOP).*

Program Integration level planning for ground and onboard configuration and operations changes to be implemented during each increment. The key product of Increment Planning is the Flight Increment Plan (FIP). The FIP will contain increment-specific operations information pertaining to the preparation for and execution of manned based activity during that increment, and will serve as a "template" authorizing overall ground and onboard personnel and equipment resource utilization.

Increment Change Managers are responsible for developing the plans and schedules for specific increments and are supported by an Increment Management Team (IMT).[13] Typical responsibilities of the Increment Change Manager will include: directing and expediting plans for the accommodation of manifested users, defining key systems operations and maintenance events during the increment, integration of transportation and data systems needs and capabilities, identification of any increment-unique requirements for logistics operations (including prelaunch or postlanding processing), and to identify the specific ground operator and crew skills required to support the increment schedule.

Because of the more detailed technical content of the FIP as compared with the TOP, there will be greater input from the Program's operations support organizations. As examples, systems resource availability templates are developed by the Space Station Support Center (SSSC). Planning support for user activities is provided by the Payload Operations Integration Center (POIC), with guidance from the Investigators Working Group (IWG - the users manifested on a specific flight increment). The IMT will then integrate the system and user requirements, and the Increment Change Manager will submit the FIP to the POCB for approval. (The POCB will be concerned primarily with increment-to-increment consistency and ensuring a smooth transition.)

The FIP will then serve as the basis for detailed Increment Execute Planning by the various operations centers. Increment Execute Planning entails preflight development of detailed operations and utilization execution plans and related procedures, schedules, and data. Such plans include the Increment Operations Plan (IOP), Flight Data File (FDF), Increment Hazard Control Plan (IHCP), Flight Rules, Reconfiguration Data and other real-time execution plans and supporting documentation as called for in the FIP.[14]

III.A.4. OPERATIONS EXECUTION

Operations Execution includes the detailed tasks associated with implementing the various execution plans and flight increment schedules established by the Increment Execute Planning process, and applying these to the three major areas of Station activity: logistics operations support, space operations and space operations support. These activities will be performed at NASA support centers, as well as at international partner and user operations facilities. These facilities include:

Space Station Support Center (SSSC): The SSSC is a Program-supplied facility which provides for centralized systems management and control for the manned base, including the elements provided by the partners. Crew and manned base safety are SSSC responsibilities as well. The SSSC provides the systems "templates" for development of TOPs, FIPs and increment execute plans and data. It integrates and approves the payload activity schedules developed by the POIC (see below). Crew training facilities are closely associated with the SSSC (and POIC). International partners will support the conduct of operations for their elements by providing responsible flight control staff at the SSSC, as well as providing real-time engineering support from facilities located in their own countries. The SSSC will normally be transparent to the user community during routine payload operations.

Payload Operations Integration Center (POIC): The POIC is a Program-supplied facility whose major function is to coordinate user activities for the manned base, building on the template provided by the SSSC. It integrates the user requirements according to user resource envelopes, assists users in periodic "replanning", aids the IWG in user conflict resolution, and supports the various user facilities in real-time or near real-time execution activities. On-orbit crew time and other resources available for users are managed by the POIC in cooperation with the SSSC.

User Operations Facilities: A variety of user-supplied and operated facilities are envisioned to meet specific needs of the users. They can be equipped to support the range of user operations involved in payload management (i.e., planning and execution related to command, control and communications for experiments, data analysis and storage, etc.). These facilities shall be established according to user preference. However, the SSOTF foresees three basic

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[13] *The Increment Change Manager, with support from the IMT membership, formulates and integrates operations policies and preparations across the Program for all configuration and operations changes which affect the assigned increment. The IMT is composed of the following members: STS and Station Flight Directors; Payload Operations Director; Payload Accommodation Manager; Station and STS crew; Program Scientist from the Program Integration level organization; Sustaining Engineering Manager; Station Launch Site Support Manager; STS Launch Site Flow Manager and key processing team representatives; Logistics Support Manager; Network Director and key data system team representatives; and STS Payload and Flight Integration Managers. These members provide the Increment Change Manager with the range of expertise and data necessary to perform the Increment Planning function.*

[14] *Increment Execute Planning also includes real-time replanning of operations on orbit. Such replanning will be necessary to support users who wish to deviate from their plans in response to such factors as unanticipated experiment results or equipment malfunction. Replanning will also be necessary for potential system malfunctions or failures.*

approaches: (1) Discipline Operations Centers (DOCs); (2) regional operations facilities; and (3) stand-alone or proprietary User Operations Facilities (UOFs) maintained by a single user or group of users.

DOCs are user supplied and operated facilities which provide support to a discipline user group which is centered around a specific area of investigation.[15] They are intended to allow for the sharing of technical support and overhead costs to users with similar discipline needs. The DOCs will interface with the POIC for coordination of their payload planning activity. Examples of discipline categories include materials science, life science, technology development, and earth observation.

Regional operations facilities incorporate both Regional Operations Centers (ROCs) and affiliated DOCs. The ROCs are user (or partner) supplied and operated facilities which are geographically focused to provide support to regionally-based user groups.[16] The intention is to share common overhead costs or technical interests with regionally grouped users. Regional operations facilities will interface with the POIC for support in scheduling and real-time replanning activities.

Stand-alone or proprietary UOFs may be desired by certain users willing to pay for the added privacy of a dedicated facility. They may be physically co-located at NASA or partner sites, or at user-selected industrial, research or academic sites. Each facility may be affiliated with a DOC or ROC, or may independently report directly to the POIC for integration of their plans and requirements with those of other users.

Space Station Processing Facility (SSPF): The Program-supplied SSPF will do the prelaunch processing of all Space Station hardware to be transported to orbit via the STS. (Similar facilities will exist at other launch sites.) The SSPF will perform all interface and safety verification testing for the Program before delivering payloads and carriers to the transportation operations organization for STS or ELV integration.

Payload integration will be performed in a "modified ship and shoot" mode. Users may build and/or integrate racks and experiments at "Science and Technology Centers" certified by the Program. These centers may be located at NASA field centers, partner facilities, or UOFs, and are likely to evolve from existing institutional payload development capabilities. Launch sites will also have a capability to build up and/or integrate payloads for users. All payloads and orbital replacement units (ORUs) will undergo final interface testing at the launch site.

Logistics Operations Center (LOC): Logistics support operations are located and managed at the launch site. The Program-supplied LOC will be responsible for the development of the manned base increment maintenance plans and assuring that the procedures, tools and materials to support these plans are available on time. In addition, it will be responsible for the storage, inventory management and maintenance of all Station system parts and payload carriers. This includes supporting a line item population on the order of 300,000 items including 2500 ORUs. A key feature of the LOC will be its extensive use of automated test equipment for in-house maintenance and repair.

Engineering Support Centers (ESCs): Located at NASA and partner hardware development centers and the launch site, these Program-supplied "facilities" will provide engineering and real-time consultation support on an on-call basis.[17] They also will perform sustaining engineering in the Development and early Mature Operations Phases. The SSOTF Framework calls for development of a transition plan which would eventually centralize sustaining engineering for U.S. orbital elements at KSC during the Mature Operations Phase. Sustaining engineering for partner orbital elements and for ground support systems and information systems would remain distributed to the partner sites and U.S. operations centers, respectfully.

III.B. PLATFORM OPERATIONS

The SSOTF recommends that the unmanned platforms be operated by the contributing partner and separate from the manned base to provide maximum flexibility in user operations. Long term operations planning will be coordinated with that for the manned base, but tactical and execution level activities will be largely independent, except for the servicing and maintenance of co-orbiting platforms at the manned base. Platform operations will be managed in a manner similar to current unmanned satellite programs, with extensive support for user telescience operations.

It is anticipated that platform increments (the time between STS or manned base maintenance and servicing activity) will vary greatly in duration, depending on platform mission objectives and planned orbital lifetime. This results in the need to maintain a flexible approach to the flow of utilization and operations planning documentation at all management levels. Given the temporal scope of the CUP (five years) and the TOP (two years) and the fact that platform increments are, in any case, much longer than their manned base counterparts, a platform's planning documentation will either consist of a CUP, a TOP and

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[15]The Task Force assumes that the "DOC format" will be used primarily in the U.S., although there is nothing which would prevent foreign users from using a similar approach.

[16]The Task Force assumes that this is the type of organizational approach which will be used by NASA's partners.

[17]It is anticipated that the "ESC" concept relates more to the capability of a center to provide ongoing engineering support than it does to provision of a dedicated "brick and mortar" facility at the center.

the various execute plans and data, or simply of a CUP and the supporting execute plans and data. A manned base-type FIP will not be required.[18]

The Platform Mission Manager leads the Program Integration level planning process (similar in many ways to the Increment Change Manager's role in supporting the increment planning process for the manned base). As in the manned base Framework, the Program will assign a Payload Accommodation Manager (PAM) to assist users through the planning process, as well as the integration, testing and verification of the user's payload.

Once on orbit, platform operations are subject only to infrequent changes in configuration (i.e., "transfer operations"), and do not have frequent/routine visits by the STS or servicing from the manned base and their crews. When these changes do occur, they are reflected in a separate Platform Transfer Operations Plan (PTOP). For COP servicing, the Platform Transfer Operations Plans are fully integrated into the manned base planning flow.

U.S. platform payload and platform transfer operations will be managed and controlled by a Platform Support Center (PSC). The PSC functions for platform systems control and user support are analogous to the SSSC and POIC functions in the manned base. Support to users for payload operations will be coordinated in the PSC by the Platform Payload Operations Center (PPOC). Actual payload operations will be performed by individual users in user facilities. Platform transfer operations will be planned and conducted in the PSC by the Platform Transfer Operations Center (PTOC). The PTOC will support specialized servicing planning requirements and interface with the manned base and STS increment planning activity. Transfer operations will be managed by the STS operations organization when the STS or STS-based OMV is the servicing vehicle, and by the SSSC when these operations are performed by the Station-based OMV, and when the COP is brought within the 20 nm command and control zone for servicing at the manned base.

As with the manned base, platform operations will be supported by the Program's Engineering Support Centers (ESCs), Logistics Operations Center, Space Station Processing Facility, and the space transportation system(s). The Space Station Information System supports user telescience requirements by providing direct access to platform payloads.

III.C. ROLES AND RESPONSIBILITIES

Figures 6 and 7 provide a summary overview of the entire planning flow from the strategic level through operations execution for both the manned base and platforms. The following operations roles are recommended to be assigned to the designated support centers and international partners for the Mature Operations Phase:

Program Policy and Integration functions are performed at NASA Headquarters. The SSOTF assigned these functions to headquarters for many reasons. These include the ability to provide a single interface for issues affecting the international partners; the necessity to manage and integrate the operations of multiple operations centers; the need to establish close coordination at senior management levels between the Space Station, space transportation, communications and data services, utilization, and operations planning organizations; the need to integrate long term planning for operations with the budget development process; and the need to strengthen Program management. NASA leadership in these functions is predicated upon NASA's larger resource contribution to Program development and operations, and on NASA's significantly greater experience in manned space flight operations.

Integrated logistics functions are located at Kennedy Space Center. This assignment takes advantage of KSC's depth of experience in NASA manned programs (including prelaunch and postlanding processing, logistics and transportation services). It also offers the opportunity for synergistic benefits by coordinating with the logistics support and payload processing and integration activities already performed by the STS organization at KSC.

Manned base systems operations and overall crew operations responsibility (including the SSSC) is assigned to the Johnson Space Center. This will allow the Program to efficiently utilize JSC's expertise as the lead manned space flight operations center. It also offers the opportunity for synergistic benefits by coordinating STS operations activities facilities, crew support and training with the Space Station Program's counterparts.

Manned base user operations and payload servicing requirements integration (including the POIC) is delegated to the Marshall Space Flight Center. MSFC is the development center for the U.S. laboratory module and will have developed the detailed "corporate knowledge base" for this user-oriented element. MSFC also has existing expertise through its role in the Spacelab Program and its associated Payload Operations Control Center. Finally, the SSOTF felt that assignment of user operations integration activities to MSFC would establish a stronger "user-directed" activity than would be the case if it were co-located with system operations activities.

U.S. platform operations are assigned to the Goddard Space Flight Center. GSFC's development role for the platforms, its expertise in past unmanned systems operations, its experience in supporting the platform science and application user community, opportunities for synergy with existing platform support facilities, and the Task Force's conclusion that platform and manned base operations should be separately operated, all led to this decision.

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[18] *In the case where a platform is to be maintained and serviced by the STS or manned base at intervals greater than two years (i.e., an increment duration beyond the scope of the TOP), the CUP data is used directly to generate execute plans and data; in the event the interval is less than two years, a TOP will be required as an interim step to define multi-increment servicing and maintenance requirements.*

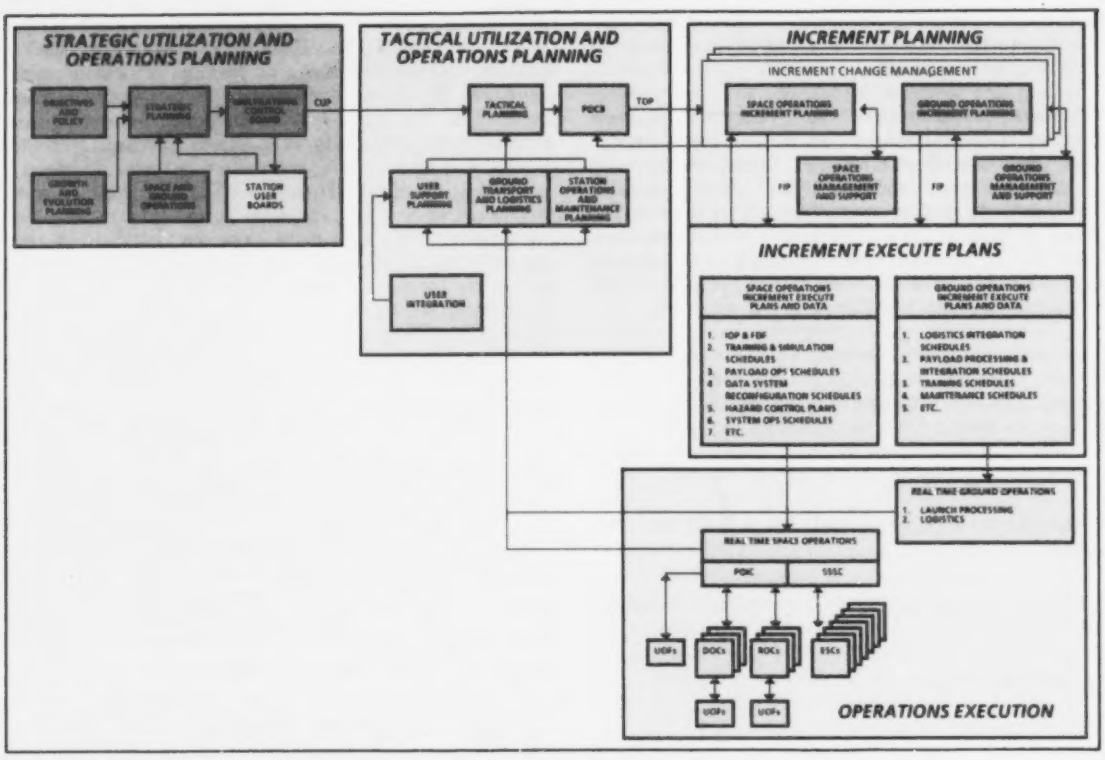

Figure 6 Summary: Manned Base Operations Framework

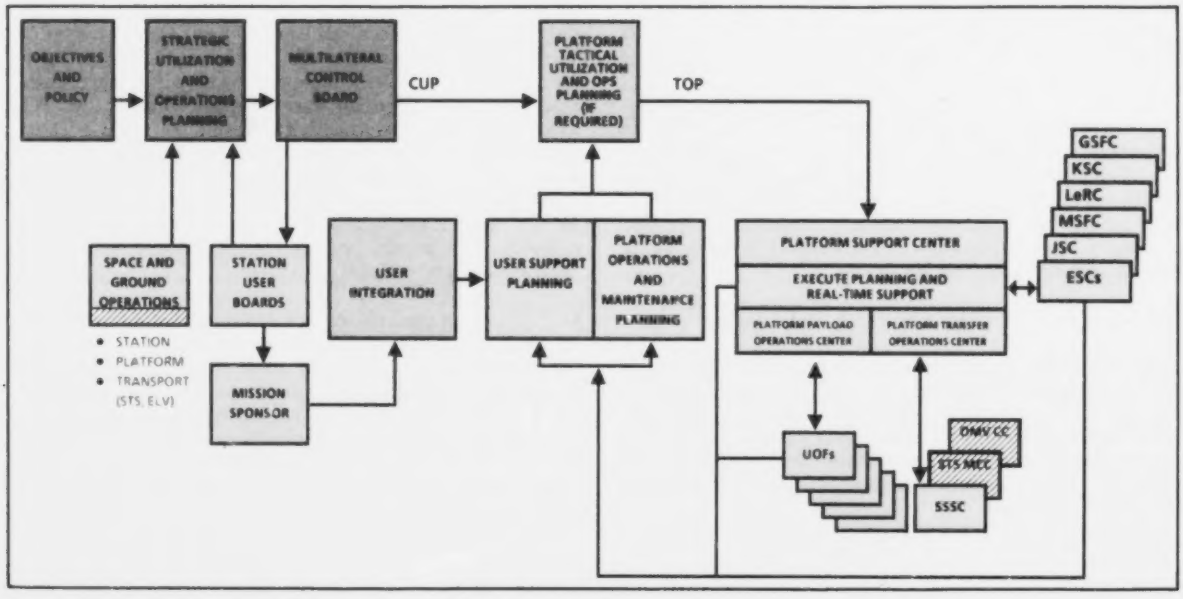

Figure 7 COP and POP Mission Operations Framework Overview

ESA platform operations are assigned to the European Space Agency for the same reasons that the U.S. platforms are assigned to GSFC. In addition, it was noted that ESA plans to develop a European Data Relay Satellite (EDRS) and associated ground systems would undoubtedly require close cooperation between the ESA platform operator and the EDRS development organization.

Engineering support is distributed to the NASA field centers and international partner organizations responsible for the development of the major Station elements (MSFC, JSC, GSFC, LeRC, KSC, ESA, Japan, and Canada). It was judged that this would offer potential synergies both in terms of initial development and operations of the Station elements, and also in planning and implementation of system evolution.

IV. SPECIAL TOPICS

In addition to the Program recommendations listed in the following section, the SSOTF examined a number of "special topics" related to the operations environment. These topics generally cover issues which lie beyond the management responsibility of the operations organization, but which nonetheless will have a strong influence on the operations environment. This section summarizes the topics; detailed analysis is provided in Chapter IV of the Summary Report.

IV.A. PROGRAM OBSERVATIONS

The SSOTF took the CETF Space Station configuration largely as a "given": however, as part of its charter the SSOTF was asked to evaluate the adequacy of that baseline to meet user and system requirements. In its analysis, the SSOTF identified several potential trouble spots which could reduce operational flexibility. Areas which are in need of further study include: (1) adequacy of the STS as the sole launch vehicle to support Station launch requirements; (2) projected shortfall in downweight capability; (3) the requirement for an emergency return vehicle in the event of extended orbiter downtime, crew health emergency, or major manned base system contingency; (4) the adequacy of onboard environmental monitoring for the manned base; (5) interoperability of ground support facilities (e.g., SSSC/POIC and PSC); (6) lack of a policy for spares or the loss of a critical element; (7) desirability of using the orbiter to service the polar platforms; (8) procedures for ensuring commonality in Station design and operations procedures across elements of the manned base; (9) tradeoffs in augmenting space network support to provide continuous acquisition of signal during manned base operations; (10) creation of an integrated logistics system for the entire Program; and (11) definition of standards for on-orbit medical capabilities, including possible inclusion of a surgeon.

IV.B. PROGRAM OPERATIONS COSTS

Several cost-related issues were identified with regard to operations costs. First, the SSOTF identified several new capabilities required to support the Recommended Framework, and noted that several facilities have been underscoped in the baseline requirements. The Task Force concluded that the Program should adopt an annual operations cost estimating process. This process would support life cycle cost estimations and related incentives evaluations essential to the Phase C/D engineering design-to-cost efforts. In addition, it would support operations risk assessments as they relate to life cycle costs which have not been emphasized in earlier development and operations cost exercises.

As a first effort, the Program should consider formalizing development of an operations cost model to provide systematic assessments of tradeoffs between design and operations on the one hand, and operations costs as they are affected by alternative management approaches.

The Task Force noted potential problems with regard to the sharing of operational costs among the international partners. As a general rule, the Task Force considers it desirable that the partner who designs and builds a piece of equipment should be responsible for the costs specific to that equipment. A related issue is the potential for U.S. subsidization of international operations resulting from the integrated operations concept for the manned base. It may not be possible to assign exact allocations of overhead costs, and some subsidization may result. The effect may be minimized by improving systems for tracking actual use and estimating each partner's share.

IV.C. INTERNATIONAL ISSUES

As noted above, a major Program goal for NASA's partners is the development of a manned space systems operations experience base which would support their future independent manned space activities. ESA and the Japanese have suggested that the manned base be managed on the basis of "element operations" in which each partner would plan and control the activities which transpired in the hardware which it provided. As noted above, this option, while technically feasible, was rejected by the SSOTF in favor of an integrated operations concept.

IV.D. PROPRIETARY USER OPERATIONS

Proprietary user operations are expected on the Station complex. U.S. and international users will need to protect any activities that are covered by government controlled technology transfer regulations or which involve corporate information security. Additionally, the Department of Defense may require proprietary protection for sensitive research activities. The SSOTF accommodated these requirements wherever possible in the development of its operations procedures.

Proprietary user operations will affect all types of operations activities, on the ground and onboard the Station. The major requirements for users include secured data transmission capabilities, physical isolation of experiments (and possibly crew) onboard the manned base, the possible use of private or bonded astronauts, and secured prelaunch and postanding facilities.

The operational requirements of the U.S. Department of Defense were considered within the context of proprietary operations. DoD was considered by the SSOTF as a strongly proprietary user, but other operational requirements (e.g., impact on SSP ground facilities) were not addressed. This approach allowed the SSOTF framework to accommodate the R&D activities identified by DoD as its primary use of the Space Station.

IV.E. STATION/STS OPERATIONS SYNERGY

There is an obvious and close relationship between the planning and operations of the STS and the Space Station Programs. There exist numerous areas of synergy where collaboration can improve overall efficiency. The possibility of realigning NASA's internal management so as to improve the agency's management of operational programs is the subject of the Space Operations Task Force, headed by NASA Associate Administrator for Operations, Robert Aller. The SSOTF did not attempt to replicate this assessment; rather, it noted those areas where Station and STS operations functions joined or overlapped. In these areas, the SSOTF recommends continued study and that the Station and STS organizations attempt to develop common policies, procedures and specifications, wherever such standardization would enhance utilization and operations capability.

It was noted, however, that commonality between the two programs could have some negative aspects. First, the SSOTF cautions that consolidation could result in counterproductive "torquing" of Station operations if non-standard STS procedures and formats are used as the baseline. Second, the Task Force was concerned about the potential to use the operations funding of one program to help correct present or future problems in the other. In short, the Task Force suggests that any efforts to implement synergy be baselined on the most efficient approach, and such relationships should attempt to isolate or "fence off" funding devoted to the respective programs.

IV.F. SAFETY

Safety requirements definition and documentation will be a NASA-controlled function for the manned base. Platform safety requirements will be the responsibility of the contributing partner. The overall safety review process is divided into two major areas: systems safety (all Station elements) supported by the Systems Safety Panel, and payload safety supported by the Payload Safety Panel. The two panels will report to the Program Integration level Program Safety Review Board (PSRB) under the auspices of the Operations Safety Office. The safety certification process for both will be similar to the process used in the STS Program, except that the PSRB will be chaired by an independent safety officer appointed by the Headquarters SRM&QA organization (Code Q). The SSSC will have overall responsibility for inflight operations safety controls, while the POIC will be responsible for monitoring prescribed user safety requirements.

As part of the safety review process, an Increment Operations Safety Review will be conducted prior to each manned base or platform increment launch. The SSSC and PSC, respectively, will be responsible for integrating the systems and payload hazard plans into an Increment Hazard Control Plan (IHCP) for each increment. The IHCP will document all operationally-controlled hazards associated with the increment, and the specific procedural measures which eliminate them.

In addition to recommending a consolidated space systems and user payloads safety review process, the SSOTF made a number of general observations on Program safety. In order for the review process to be enforced, the Program should provide an adequate level of safety indoctrination for professional operators (crew and ground personnel), users and other support personnel. Only through the assimilation of safety requirements and standards by those operating the Station element systems can a high degree of security in operations be ensured. Finally, the SSOTF concluded that there is a need to develop quantitative methodology for performance of safety risk assessments. Such methodology would help to reduce the dependence on conservative assumptions which could unnecessarily reduce operations flexibility.

IV.G. PRICING POLICY

Industry experience and the STS pricing policy debates have shown that pricing structures can have decisive effects on the behavior of providers and consumers of complex services. Thus, it is important to assess the overall programmatic and political goals that a pricing strategy is to accommodate before developing the strategy itself. Since these goals are set by agents outside of the Space Station Program (primarily the Administration and Congress), the Task Force examined the effects that different policies would have, but did not recommend a particular approach.

The Task Force identified two possible objectives for a Space Station pricing policy which were considered most appropriate:

1) Primary emphasis on recovering NASA funds, while encouraging Station use.

2) Primary emphasis on promoting efficient use and management of the Space Station.

Federal law requires that agencies offering services that offer a particular benefit to one group, individual or industry must recover "all reasonable costs" incurred in providing these services. Traditionally, NASA has interpreted this requirement to mean that prices must be based on some measure of actual program costs.

A less traditional approach to pricing NASA services would be to design the pricing structure to reflect demand. Scarce resources would be priced higher than those for which there is little demand. Thus, power required at peak usage times would have a higher price than the same power during a period of low-usage. This approach could be taken one step further by establishing an auction or some similar method for selling Station resources.

The question of which Station resources are to be measured and priced separately will have a strong effect on the overall efficiency of the pricing approach. There are three options regarding this issue: (1) monitoring and charging separately for each and every resource; (2) monitoring and basing prices on relatively few key resources; and (3) establishing prices on some other basis.

Because of the effect that pricing can have on user payload design and planning, it is necessary that a pricing policy be established before major development efforts are underway. With a planned Station IOC of 1995, some payload development efforts will get underway in the next several years. As a result, development of a Station pricing structure (at least in broad outline) should be undertaken immediately.

IV.H. CREW TRAINING

The planning, scheduling and coordination of training activities will be a major task in the Mature Operations Phase of Station operations. Training facilities and aids will be located at operational centers in all parts of the U.S. and at the international partner's sites. The possibility for overscheduling of crew personnel and facilities is very real. Hence, extensive planning and coordination of training activities, as well as the distribution of facilities supporting systems and payload operations training is necessary to prevent conflicts from developing.

For the Mature Operations Phase, a joint training coordination group is recommended. This Space Station Training Coordination Board (SSTCB) would be composed of members from all the NASA centers supporting Station activities, the international partners, astronauts, and safety personnel. This group would accomplish the scheduling and conflict resolution for all training requirements. The goals of the SSTCB would be to provide the following: coordination of training schedules and curricula; definition of training sources; definition and standardization of certification requirements and procedures; definition and implementation of commonality requirements; definition and coordination of simulation approaches and schedules; and definition and implementation of a centralized training records system. One of the major goals of the SSTCB would be to pursue and maintain common training methodologies, media, scheduling and execution among all participating organizations.

It is proposed that commonality in the training process be implemented through the following areas: training manuals/ briefings; computer aided instruction (CAI) lessons; training equipment; training for users; certification methods; and Flight Data File document formats.

Distributed (also referred to as "core") space systems training activities and facilities would be centrally located at JSC; international partners would provide additional systems training capability for their respective elements in their countries; laboratory-unique user support systems and payload operations training facilities would be distributed (in the U.S. and abroad) in those cases where proximity to users outweighs the additive costs of maintaining multiple training systems. Three major categories of training systems are recommended to be implemented. These are: team training; systems training; and payload training. Team training applies only to the manned base in support of flight crew activities. Systems training and payload training apply to all elements of the Station Program.

IV.I. THE SPACE STATION INFORMATION SYSTEM (SSIS)

The SSIS will be an end-to-end data and information system for the Space Station Program and its users. It is important to understand that SSIS will not be an "all-new," completely dedicated "system" for the Program. Rather, the SSIS is better characterized as a concept or virtual network consisting of both existing and planned operational elements provided by NASA, the international partners, and users of the Space Station.

The basic SSIS elements will be provided by different organizations both within and external to NASA. Additionally, not all of the capabilities required by SSIS are dedicated to Space Station activities (e.g., TDRSS and NASCOM support all near-earth orbiting NASA spacecraft). These factors pose complex management and integration problems for the Program. To assist in resolving these problems, the Task Force recognized the need to have a single organization responsible for definition and control of SSIS architecture requirements.

The SSIS is a critical, and limited, resource in support of Program operations. Since SSIS is an international network with various elements being provided by different organizations, early and effective information systems planning is vital to successful operations. In developing the CUP, TOP and FIPs, Program system requirements and user requirements must be balanced against SSIS capabilities to ensure the system is correctly configured to provide the necessary end-to-end support.

The Task Force SSIS architecture differs somewhat from that of the currently baselined SSIS Architectural Definition Document. However, these differences are more in terms of functional capability or capacity, nomenclature, and location of ground facilities than they are to changes in basic philosophy of the SSIS as an integrated operations information management system. Specific architectural differences are presented within the SSOTF Summary Report along with associated recommendations which the SSOTF endorsed as significant drivers relative to early Development Phase ground and onboard systems design activity. More detailed recommendations relative to SSIS design and operations may be found at the panel report level, and endorsement and implementation are left up to the appropriate development organizations.

IV.J. THE SPACE STATION MANAGEMENT INFORMATION SYSTEM (MIS)

This section suggests areas in which the MIS is required to support overall Program management. As

a result of the Technical Management & Information System (TMIS) Information Analysis task, 28 top-level, key database categories were developed. Existing databases have generally been scoped to match the requirements of the Development Phase of the Program, and are underscoped relative to the information required to support ongoing operations planning and execution in the Mature Operations Phase.

Given the complexity of the manifesting process and the numbers of variables involved, it also appears necessary to provide state-of-the-art tools to enable planners to perform trades among the variables affecting each increment plan. For example, there are finite test and integration capabilities at the launch sites. There are also finite storage areas for payloads and cargo either awaiting checkout or those that have completed checkout and are waiting to be integrated into the launch vehicle. Developing optimum schedules for the flow of this material through the launch site facilities is a typical logistics operations support problem. Another example where this type of technology will prove useful is in the management of changes to manifests. For instance, if a manifested payload (with certain mass, volume, and power requirements) cannot be delivered as originally scheduled, what substitute payload(s), can be inserted into that particular launch schedule with the minimum of impact on orbiter processing flows, orbiter and payload Flight Data File preparation activities, Space Station operations, and user operations?

The Task Force identified several potential databases for both orbiting systems and ground systems. Key among these will be hierarchically consistent data sets of operations performance, cost performance, and program risk assessments. Other databases capturing the "design knowledge" of the Development Centers and their contractors must also be established and maintained throughout the Development Phase. These data will be used in analyses supporting near-term operations management as well as developing plans for evolution of Station elements.

Ready access to data and information can be most effectively accomplished through Program-wide definition of database standards. It is essential to define common data types and characteristics. However, dissimilar database architectures may be used to support specialized functions if the data characteristics are preserved across interfaces and translations among databases. Thus, the design goal for SSP databases should be to ensure commonality and uniformity of data sets, units of measure, and representation formats (both data content and level of detail) without constraining programming languages and user interfaces. This will be particularly important as the Program seeks to achieve interoperability among the operational SSIS, TMIS, Software Support Environment (SSE), and other existing data and information systems.

As noted in the introduction to this section, TMIS and other systems such as SSE, can provide some of the tools and connecting systems necessary to perform the task, but it will be the responsibility of the various Program and Center organizations to actually develop the databases, enter the data, and perform database maintenance and control. The Program will also have to develop special tools, such as the state-of-the-art operations analysis tools mentioned above, independent of TMIS and the Phase C/D Work Package contracts.

V. RECOMMENDATIONS FOR IMPLEMENTATION

The following list comprises the official recommendations of the SSOTF. They fall within five broad categories: (1) Program Operations Management Recommendations; (2) Space Operations and Support Recommendations; (3) User Integration and Accommodation Recommendations; (4) Logistics Operations Support Recommendations; and (5) Systems Development Recommendations. The first four categories contain recommendations pertaining to implementation of the operations framework as described in this Summary Report; the fifth category contains several systems "design-to" type recommendations derived from the individual panel reports and are fully supported by the SSOTF.

Program Operations Management:

1. Immediately baseline the Space Station operations framework as described in this SSOTF Summary Report. Appropriately revise existing Program documentation to reflect this baseline.

2. Implement the Station operations management organization structures for the Development and Mature Operations Program phases as detailed by the SSOTF Summary Report (reference Figures 8 and 9, respectively), including the following highlights:

   A. Separate utilization and operations organizational and budgetary functions from space systems development and budgetary functions at the Program Integration level for transition, and the Associate Administrator level for mature operations

   B. Establish the Office of Director, Utilization and Operations at the Program Integration Level.

   C. For mature operations, provide an Increment Change Management Office at the Program Integration Level to manage all aspects of preflight planning with the delegated authority of the Director, Utilization and Operations.

   D. Identify the organizational elements as well as the Program control and support responsibilities at each management level. At the

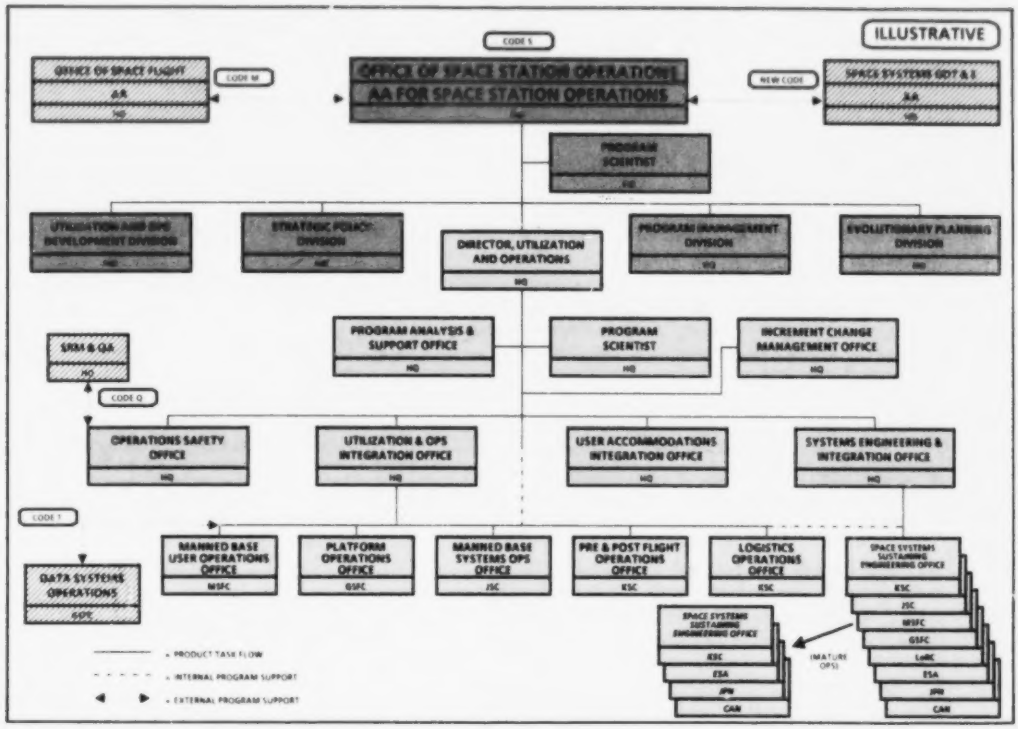

Figure 8 Space Station Program Mature Operations Organization

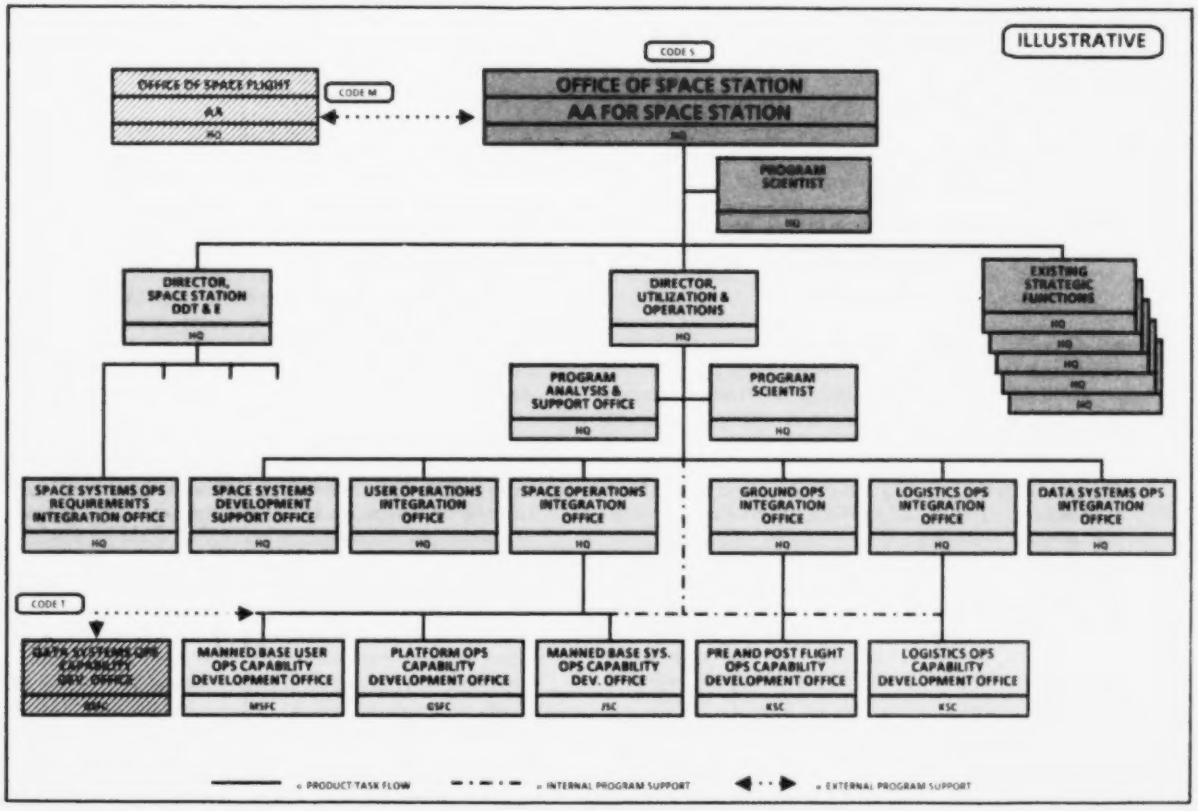

Figure 9 Space Station Transition Operations Organization

Program Execution level, allow implementation flexibility with regard to project vs. matrix support structure.

3. Implement the following NASA support center functional assignments:

   A. Program integration and control: NASA Headquarters.

   B. For the manned base, integration of user operations and servicing requirements and plans: the Marshall Space Flight Center (MSFC).

   C. For the manned base, integration of space systems operations requirements and plans as well as integration of space systems and MSFC-provided user operations requirements and plans: the Johnson Space Center (JSC).

   D. For the manned base and platforms, integration of logistics operations support requirements and plans: the Kennedy Space Center (KSC).

   E. For the U.S. platforms, integration of all space and user systems requirements and plans: the Goddard Space Flight Center (GSFC).

   F. For the manned base and platforms, provision of sustaining engineering for the orbiting elements and systems: the Lewis Research Center (LeRC), MSFC, JSC, GSFC and KSC as appropriate to Program responsibilities for element and systems development.

4. Develop specific implementation requirements, plans and schedules for the ground facilities which the SSOTF recommends for Space Station operations support, to include:

   A. Construction of a phasing plan that identifies those facilities which are mandatory to support first element launch and those whose readiness may be phased in to support subsequent assembly operations.

   B. Identification of requirements, if any, for those facilities which the SSOTF identified as questionable.

   C. Inputs to the construction of facility process including schedules and priority assign-ments.

   D. Development of a cost-sharing approach between the STS and Space Station Programs for those facilities which are shared.

   E. Identification of those Station Program facilities built to support the Development Phase of the Program which will be required to support ongoing sustaining engineering operations.

5. Establish and document the Program configuration control processes at each organizational level as required to implement this SSOTF Operations Framework. Further develop the content, scope and framework for the Consolidated Utilization Plan, the Tactical Operations Plan, and the Flight Increment Plans, and determine specific organizational responsibilities, interface protocols, information systems requirements and schedules for their production and review.

6. To facilitate Program operations life cycle cost projections:

   A. Conduct an operations costs estimation study with each participating operations organization using the center assignments, facility requirements and overall operations framework described in this Summary Report.

   B. Develop a process for estimating annual operations costs which accounts for all elements of the operational framework as described within this Summary Report.

7. Ensure that the Program Integration level (NASA Headquarters) of the Station Operations organization retains control of the overall SSIS architecture, including SSIS interface with both the TMIS and SSE operational support systems. This includes control of all requirements affecting the various nodes of the SSIS network. Further, to ensure SSIS interface compatibility with user telescience requirements, a user telescience scenario should be developed by the Program as a reference against which SSIS capabilities can be assessed and technology trades conducted.

8. The SSOTF emphasizes the need for development of a TMIS that fully supports all aspects of this operations framework during each Program phase. The technical and political difficulty of achieving present and future interoperability between NASA and partner operations support centers, and between the Space Station and STS Programs, represents a significant Program challenge which must receive the early and continued attention of top NASA management. Crucial to the success of such an effort is the early identification of the various Program databases (engineering and operations) required to support the Program's Development Phase; these databases will serve as the point of reference for each organizational level as the Program transitions to the Mature Operations Phase.

9. Develop an equitable policy regarding sharing of operations costs among the partners. This policy must be straightforward and easily implemented and should consider individual partner resource allocations, sustaining engineering responsibilities, and overall contributions to routine Station operations.

10. Develop an equitable pricing policy for utilization of Station resources. This policy must be straight forward and easily implemented and should cover

the variety of anticipated government and non-government users of the Station, both domestic and foreign.

11. Upon joint approval of the NASA/partner MOUs regarding international cooperation in the Space Station Program development and operations phases, immediately begin to integrate international participation at all levels of the operations organization.

12. Establish an operations performance assessment system available to each level of Program management which identifies symptoms of non-optimal performance as well as decision path alternatives which, if implemented, could improve ground and onboard operations effectiveness.

Space Operations and Support:

13. Baseline the following criteria relative to flight crew composition and skills emphasis:

    A. The Director, Utilization and Operations, shall have final approval authority for selection of all manned base crew members.

    B. The manned base shall have a commander who is a NASA career astronaut.

    C. Manned base crew members shall be assigned, trained and integrated on board as an integrated team.

    D. Scientific credentials shall be considered paramount when selecting candidates for Station Scientist positions.

14. Immediately establish a multicenter/multinational Training Coordination Board to integrate advanced planning activities associated with the use of all crew training facilities supporting the Space Station Program.

15. U.S. and ESA Platform operations planning should be the sole responsibility of the sponsoring partner below the Program Policy (strategic planning) level. Further, the platforms should operate independent of each other and of the manned base, except for proximity servicing operations of co-orbiting platforms at the manned base.

16. Ensure that there is a full backup capability to the Station ground command and control network to cover environmental and technical contingencies affecting routine Station operations.

17. The Program should develop a single element loss and recovery program plan applicable to the assembly phase.

User Integration and Accommodation:

18. Establish an independent (external to the Station Operations organization) U.S. Space Station User Board (SSUB), reporting to the NASA Administrator and supporting the Associate Administrator for Space Station Operations in strategic planning for Station utilization. Membership on the SSUB should be at the Associate Administrator (or equivalent) level as determined by the NASA Administrator, and responsibility for chairmanship should rotate annually among member organizations. Additionally:

    A. Develop NASA policy for the SSUB charter including specific protocols for its interface with the Space Station Program.

    B. Encourage each international partner to establish an analogous user board with similar functions and protocols for interface with the Space Station Operations organization.

    C. Establish the SSUB process for allocating U.S. and partner resources to the various Station user sponsors.

19. To facilitate user accommodation and integration within the Program, provide a cadre of Payload Accommodation Managers (PAMs) accountable to the Program Integration level (NASA Headquarters) of the Operations organization. Each PAM will be a senior utilization and operations advocate who will serve as the primary liaison between each selected user, the Station and the appropriate transportation system program.

Logistics Operations Support:

20. As a means of reducing Station dependency on the STS:

    A. Provide an independent means of Station crew recovery which satisfies Program requirements for accommodating on-board medical contingencies as well as for rescue of the total Station crew.

    B. Provide an independent means of logistics support to the Station. Study the feasibility of the following as potential "design solutions":

    -- Independent cargo return: STS-launched logistics carrier with either a recoverable ballistic or a controlled atmospheric destruction reentry capability;

    -- Independent cargo resupply and return: ELV launched logistics carrier with an auto rendezvous and/or OMV retrieval capability, and either a recoverable ballistic or a controlled atmospheric destruction reentry capability.

    C. Perform cost trades on "throwaway" versus STS-serviceable polar platforms.

    D. Perform cost trades on standard versus non-standard ORU and payload interfaces for STS and ELV launch vehicles.

21. Establish a distributed approach to payload integration which allows:

A. Payload-to-rack and payload-to-PIA integration and functional operations verification at Program-designated NASA and partner Science and Technology Centers.

B. Rack-to-element integration and interface verification at the launch site.

C. Integrated operations end-to-end checks on-orbit.

22. Initially establish a distributed approach to space systems sustaining engineering which allows:

A. Space systems sustaining engineering performed by appropriate NASA and partner development centers as defined in Table 1. (For the U.S., this represents the Development Phase work package assignments.)

B. NASA Headquarters coordination at the Program Integration level.

C. Gradual centralization of sustaining engineering functions at KSC, commensurate with Program management determination that the corresponding space systems have reached their performance maturity.

Systems Development:

23. Add a second Ku-band system on the manned base as a backup to normal operations and to enhance operability by minimizing TDRS hand-over dropout.

24. Increase Ku-band antenna size or radiation power to accommodate full forward link TDRS bandwidth of 25 mbps, or provide effective TV compression techniques within the available reduced bandwidth.

25. Provide for operational use of S-band and consider assignment of critical manned base systems and crew operations functions to this band. This would provide for interoperability with international relay satellites and improve partner communication links.

26. Conduct trade studies to establish the potential for ground-based operators and users to have "continuous acquisition of signal" with the Station's manned base.

27. As a means of facilitating evolutionary orbital operations, develop the following additional capabilities which are beyond current baselines:

A. Increase allowable crew stay time through development and implementation of a medical flight duration extension program.

B. Expand the onboard environmental monitoring capability and electronically link to the manned base Health Maintenance Facility. The system should be capable of quantifying biohazards and microbial loads.

C. Investigate methods of safely increasing STS passenger capacity.

28. The Program should provide additional racks as required to support the distributed payload integration concept; the number of currently baselined racks appears to be insufficient. Additionally, rack and PIA level simulators should be provided to each Science and Technology Center to facilitate standardized payload-to-rack and PIA integration and verification.

29. Provide a capability for late pad access to logistics module pressurized volume (e.g., side hatch, access port).

30. To the maximum extent possible, the Station Development Program should achieve space systems "fit and function" commonality across all Station elements. Commonality is an effective means of reducing the operational complexity of performing Station logistics and on-orbit housekeeping tasks, thereby increasing potential for user accommodation. Commonality criteria should be developed early in the Development Phase of the Program and, subsequently, be formally controlled at the Program Integration level.

RESPONSIBLE CENTER	CATEGORY	AREA OF RESPONSIBILITY
HQS	D	• Integration of distributed sustaining engineering activities

	D	• Technical Documentation Configuration Control
		  • Integrated Elements
		  • Integrated Space Systems
		  • Sustaining Engineering Standards

	D	• Coordination of baseline space systems and GFE support systems configuration control process
	D	• Integrated maintenance data base control
	D	• Development, management and control of an integrated space systems maintenance plan
	D	• Development and implementation (following Program maturity) of a sustaining engineering consolidation plan

MSFC	A,B	• Onboard space systems as follows:
		  • Structures
		  • Core Modules
		  • Racks
		  • Logistics Modules
		  • Connect/Interconnect Apparatus
		  • Systems
		  • Environmental Control and Life Support (End-To-End System)
		  • Thermal (Internal System)
		  • Communication and Tracking (Internal System)
		  • Data Management (Internal System)
		  • Power Management and Distribution (Internal System)
		  • Outfitting
		  • U.S. Laboratory Module
		  • Habitation Module
		  • Logistics Module

	A,B	• Integrated Logistics System
	A,B	• Orbital Maneuvering Vehicle (OMV)
	A,B	• OMV-To-Mobile Servicing Center (MSCS)
	A,B	• OMV-To-Station/Platform Systems
	C	• OMV-To-Payload Systems

JSC	A,B	• Onboard space systems as follows
		  • Structures
		  • Truss
		  • STS Interface/Berthing Mechanism
		  • Mobile Transporter
		  • Airlocks
		  • Nodes
		  • Systems
		  • Data Management
		  • Communications and Tracking
		  • Guidance, Navigation and Control
		  • Thermal Control System
		  • Propulsion
		  • EVA Systems
		  • Resource Integration
		  • Crew

	C	• Pressurized volume payloads-to-Station
GSFC	A,B	• Platform Structures and Systems (Except Power)
	A,B	• Servicing Facility
	A,B	• Attached Payload Accommodations
	A,B	• Servicing Tools
	A,B	• Flight Telerobotic Servicer (FTS)
	C	• Payloads-To-FTS
	C	• Attached Payloads-To-Station
	C	• Payloads to servicing facility
	C	• Payloads-To-U.S. Platform

LeRC	A,B	• Onboard Space Systems As Follows:
		  • Photo Voltaic Module
		  • Solar Dynamics Module
		  • Station Power Management and Distribution
		  • Platform Power

KSC	A	• Launch site maintenance and modifications to space systems ORU's
	A	• Engineering analyses of logistics operations and prelaunch/postlanding operations processes in support of effective handling of space systems ORU's and supporting GFE
	A	• ORU up/down manifest development and coordination with the transportation system organization
	A	• As a delegated task from the program integration organization, development of generic standards for space systems sustaining engineering for use by all distributed ESC's
	A	• Development and management of a configuration status and maintenance history data base for each space system ORU
Canada	A,B	• MSCS
	C	• MSCS-To-Payload
ESA	A,B	• Columbus lab and associated space system
	C	• Pressurized Volume Payloads-To-Columbus Module
Japan	A,B	• Japanese Experiment Module/Exposed Facility/Experiment Logistics Module and associated space systems
	C	• Pressurized volume payloads-to-Japanese Experiment Module/Exposed Facility/Experiment Logistics Module

* A = Maintenance Engineering Responsibility
* B = Design Engineering Responsibility
* C = Payload Integration Responsibility
D = Sustaining Engineering Integration Responsibility

* Reference section III.B.2, Engineering Support Operations, for category definitions.

Table 1 Space Systems Sustaining Engineering Responsibilities

☆ U. S. GOVERNMENT PRINTING OFFICE : 1988 O - 196-989 QL.3